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Examining How Junior High School Students Understand on Vibration and Wave Topics in HOTS Questions

Kurnia Islamiyah*, Supriyono Koes-H, Ahmad Taufiq, & Annisa U. Yana
Pendidikan Fisika, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Malang
*Corresponding author: kurnia.islamiyah@yahoo.com

Abstract: *This study offers fresh perspectives on the difficulties students encounter when grasping concepts related to vibrations and waves. It highlights the need for creating more effective Higher Order Thinking Skills (HOTS) questions to enhance student comprehension.This research aims to examining the understanding of junior high school students about vibrations and waves regarding HOTS questions. The method used in this study is descriptive analysis in which 68 students of 9th grade junior high school participated and answered five multiple-choice HOTS questions about vibration and waves topic. The reliability of the questions used in this study was 0.845, indicating a high level of reliability. The results of the study showed that overall, 66% of students understand the concept of vibrations and wave, but 21% of students were categorized as very less at understanding HOTS questions related to vibration and waves well. In addition, students' ability in understanding question with indicator C6 was also the lowest when compared to indicator C5 and C4. It was concluded that a wide deficit exists among them regarding the higher conceptual knowledge of physics. Such findings could be a starting point for making necessary adjustments in curriculum and teaching methodology at junior high school physics.*

Keywords: *HOTS, junior high school, understanding, vibration and wave*

Menelaah Pemahaman Siswa SMP tentang Topik Getaran dan Gelombang dalam Soal HOTS

Abstrak: Penelitian ini menawarkan perspektif baru tentang kesulitan yang dihadapi siswa ketika memahami konsep-konsep yang berkaitan dengan getaran dan gelombang. Penelitian ini bertujuan untuk menguji pemahaman siswa SMP tentang getaran dan gelombang terkait pertanyaan-pertanyaan HOTS yang lebih efektif untuk meningkatkan pemahaman siswa. Metode yang digunakan dalam penelitian ini adalah analisis deskriptif di mana 68 siswa kelas 9 SMP berpartisipasi dan menjawab lima soal HOTS pilihan ganda tentang topik getaran dan gelombang. Reliabilitas soal yang digunakan dalam penelitian ini adalah 0,845, yang menunjukkan tingkat reliabilitas yang tinggi. Hasil penelitian menunjukkan bahwa secara keseluruhan, 66% siswa memahami konsep getaran dan gelombang, namun 21% siswa dikategorikan sangat kurang dalam memahami soal HOTS yang berkaitan dengan getaran dan gelombang dengan baik. Selain itu, kemampuan siswa dalam memahami soal dengan indikator C6 juga paling rendah jika dibandingkan dengan indikator C5 dan C4. Disimpulkan bahwa terdapat defisit yang cukup besar di antara mereka dalam hal pengetahuan konseptual fisika yang lebih tinggi. Temuan ini dapat menjadi titik awal untuk melakukan penyesuaian yang diperlukan dalam kurikulum dan metodologi pengajaran fisika SMP.

Kata kunci: Getaran dan gelombang, HOTS, pemahaman, SMP

INTRODUCTION

The vibrations and waves topic is an essential element of the physics curriculum that must be introduced in science learning. Understanding the concepts of vibrations and waves is crucial in physics, as they define many natural phenomena from sound and light waves to mechanical vibrations (Fitriani et al., 2023; Yana et al., 2020). Strengthening

students' understanding of vibration and wave phenomena is also very important, as these basic physics concepts are foundational to many real-world applications of technology and processes (Furqani et al., 2018). However, the complexity of vibration and wave phenomena and concepts that are considered abstract causes significant challenges for students, especially when faced with questions that require a high level of understanding and thinking skills such as question of the High Level Thinking Skill (HOTS) type (Drigas & Kontopoulou, 2016; Nisfah et al., 2022).

The ability to understand HOTS questions is very important for students to master in 21st century science education. This is because the urgency of the need for creative humans to think critically and skillfully solve problems is increasingly emphasized. Higher Order Thinking Skills (HOTS) are skills that include a variety of complex cognitive processes that require a deeper understanding than just remembering or memorizing (Sobirin et al., 2019). HOTS in Bloom's taxonomy is related to problem solving, critical thinking, and creative thinking (Anderson & Krathwohl, 2001; Krathwohl, 2002). HOTS can also be categorized as skills that include analysis, evaluation, and synthesis/creation (Chandio et al., 2016; Wilson, 2016). Consequently, students who understand HOTS questions well are not only able to recall facts about vibrations and waves easily, but are also able to apply their knowledge in real situations, analyze information, and evaluate arguments well.

However, the vibrations and waves topic are considered as abstract and difficult concept for students, especially junior high school students. Various previous research revealed that many junior high school students have difficulty in understanding basic concepts related to vibration and wave phenomena (Ginting & Siregar, 2022; Rosa & Widiawati, 2022). The research conducted by Wiyantara et al. (2021) on thirty grade 9 students at one of the junior high schools in Bandung also found that most students still have insufficient knowledge and tend to have misconceptions on the concept of waves. Even Astuti et al. (2020) shows that as many as 68.97% of junior high school students in Banyubiru are still at a low level in solving problems that analyze the concepts of vibration and waves.

In this context, it is crucial to know how junior high school students in Indonesia interpret and respond to HOTS questions related to physics concepts, especially vibrations and waves. Are students able to apply the concepts they have learned in different situations? Are they able to connect theory to practice? These questions are very relevant considering the importance of critical thinking skills in facing global challenges in the future. Overall, this study aims to understand how junior high school students in Indonesia comprehend vibrations and waves within the context of HOTS questions. By examining how students respond to HOTS questions, it is hoped to provide new insights into the challenges students face in understanding of vibrations and waves topic, as well as emphasize the importance of developing more effective HOTS questions to improve student understanding. In addition, the results obtained can also help educators identify potential gaps in knowledge and areas needing further development early on, as well as explore what instructional assistance or strategies are effective and relevant.

METHOD

This study employs a quantitative approach with a descriptive analysis method aimed at examining the ability of 9th grade students at SMP Islam Sabilillah Malang to understand HOTS questions related to vibrations and waves. The participants in this study consisted of 68 9th grade students from SMP Islam Sabilillah Malang during the 2023/2024 academic year. The selection of participants was conducted randomly to

ensure that the sample was representative and to minimize bias in the research findings. These students were chosen because they had previously studied the topic of vibrations and waves, making them likely to provide relevant insights into their understanding.

The measurement instrument used in this study was five HOTS questions on the topic of vibrations and waves. The question instrument used was designed in the form of multiple choices with reasons that require answers in the form of essays. This question instrument allows students to not only choose the correct answer but also explain their thinking strategies and reasons behind the answer choices. The question instrument used has gone through empirical testing and has been declared valid with a high reliability of 0.845. This means that this instrument is consistent and can be used to measure students' understanding abilities. The essay answer assessment technique used in this study follows the scoring rubric by Docktor et al. (2016), which is to determine the level of students' ability to understand HOTS questions on the topic of vibrations and waves by classifying students' total scores following the criteria in Table 1.

Table 1. Classification of Students' Level of Understanding of HOTS Questions

Evaluation Result (%)	Level of Understanding of HOTS Questions
80 – 100	Very good
66 – 79	Good
56 – 65	Enough
46 – 55	Not enough
< 45	Very less

Source: (Nurhatmanti et al., 2021)

Data collection was conducted using the paper-pencil method, where students were asked to fill in the questions provided on paper. The data collection process was conducted in one session, where students were given sufficient time to read and answer each question carefully. After all students had completed the questions, the answer sheets were collected for further analysis related to students' understanding of HOTS questions on the topic of vibrations and waves. The data obtained from students' answers will be analyzed descriptively using SPSS and Microsoft Excel

RESULT AND DISCUSSION

In general, the results of descriptive statistical analysis of the value data from 68 junior high school students showed that 66% of students understood the concept of vibrations and waves. The finding that 2/3 of students' conceptual understanding of vibrations and waves is positive is encouraging, but it also informs us that 1 in 3 students do not have a strong understanding of this topic. In line with the previous analytical studies (Koriah & Jumini, 2024; Mawaddah, 2023; Sari et al., 2024; Yana et al., 2020) which showed that most junior high school students' level of understanding of vibrations and waves is still in the medium category, these results indicate that junior high school students need additional interventions during science learning that support students' cognition to improve conceptual understanding in this topic.

The percentage of students who understand HOTS questions based on the classification of students' understanding ability levels can be seen in Table 2.

Table 2. Classification of Students Based on Their Level of Understanding of HOTS Questions

Level of Understanding of HOTS Questions	Number of students	Percentage (%)
Very good	26	38
Good	11	16
Enough	8	12
Not enough	9	13
Very less	14	21

Based on Table 2, it can be seen that 38% of students have been able to understand HOTS questions very well, 16% of students are able to understand HOTS questions in the good category, and 12% of students are in the category of enough to understand HOTS vibration and wave questions. It is important to note that 21% of students are included in the category of very less understanding and 13% of students are still having difficulty because they do not to understand HOTS questions well enough. Analysis of the classification of students' level of understanding of HOTS questions shows that there are signeificant gaps in students. Comprehension that need to be investigated further. There are indications that although students can understand the basic concept of vibrations and waves, they still struggle to apply higher order thinking skills to the concepts. The percentage of students in the “very less understanding” and “not enough understanding” categories needs special attention. This not only indicates that students lack proficiency in working on HOTS questions about vibrations and waves, but also shows that students' understanding is very limited. Not only that, but as a consequence, this group of students is at risk of falling behind in their cognitive development. The implications of this finding are substantial, as it raises questions about the effectiveness of the pedagogical approach used and the specific need for more personalized cognitive support for students during learning. The distribution of students' mean scores on each HOTS indicator can be seen in Figure 1.

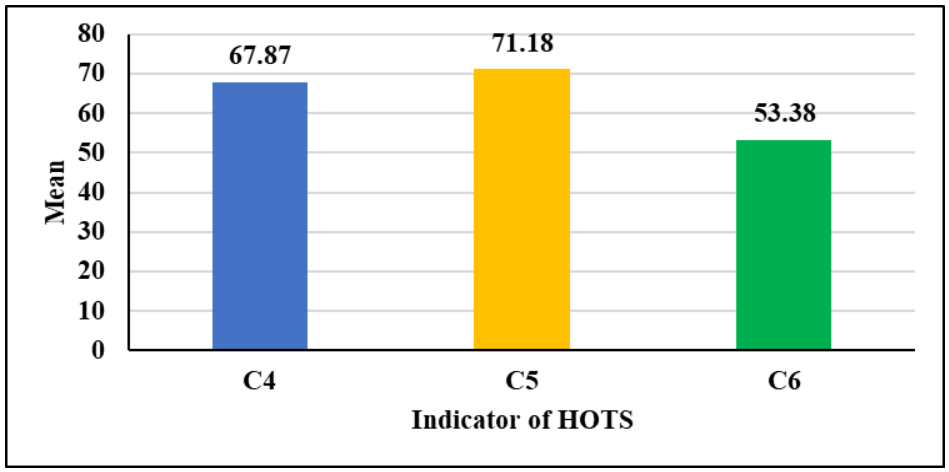

Figure 1. Student Mean Scores for Each HOTS Indicator on The Topic of Vibrations and Waves

Figure 1 shows that the mean value of students on questions with indicator C4 is 67.87, on indicator C5 it is 71.18, and on indicator C6 it is 53.38. If sorted, then on

average students find it easier to understand HOTS questions that evaluate (C5), then analyze (C4), and finally create (C6). The higher mean scores for C5 indicators compared to C4 indicators are interesting because students typically have an easier time understanding analysis questions than evaluation questions. This could be due to misconceptions in interpreting relationships between concepts and difficulties in representing solutions when working on HOTS questions with analysis indicators (Ariani, 2020). Meanwhile, the mean score on questions with the C6 indicator is the smallest compared to other indicators. This could be because this indicator requires more complex understanding compared to the C4 and C5 indicators (Anderson & Krathwohl, 2001; Krathwohl, 2002; Wilson, 2016). It may also be due to the lack of adequate instructional focus to train students' abilities on this indicator. Similar to these results, the analysis of Rosa & Widiawati (2022) states that the difficulties experienced by students while working on problems in the C6 indicator include difficulties in analyzing the magnitude of what is known in the problem so that it affects students' decisions to determine the correct stage of completion.

Furthermore, more detailed results can be seen in the distribution of the percentage of students' understanding of each HOTS question in Table 3. Questions 1 and 2 are analysis type questions with level C4. Questions 3 and 4 are evaluation type questions with level C5, and question 5 is a creation type question with level C6.

Tabel 3. Distribution of Percentage of Students' Understanding of Each HOTS Question on Vibrations and Waves**.**

Level of Understanding of HOTS Questions	**Percentage of Students on Each Question (%)**				
	1	**2**	**3**	**4**	**5**
Very Less	19	32	19	6	29
Not Enough	25	10	18	28	41
Enough	1	1	3	3	0
Good	1	4	9	7	7
Very Good	53	51	51	56	22

Based on Table 3, it can be said that the level of students' understanding of HOTS questions number 1 to 4 is almost the same, while for HOTS question number 5 it is different. In question number 1, a transverse wave graph with length and time parameters is presented. In this problem, students are asked to analyze the correct statement based on the graph. Some students are able to understand HOTS problems with this C4 indicator very well, where students are able to organize the quantities to determine the mathematical operations needed to solve the problem in the problem. However, almost half of the students (44%) still had difficulties in analyzing problem number 1. In this classification, based on students' reasoning answers, it can be seen that students have difficulty in reading graphs and distinguishing the concepts of frequency and period. In question number 2, a longitudinal wave image with length and time parameters was presented, then students were asked to analyze the correct statement. Similar to the results of the analysis of question number 1, in question number 2, the percentage of students who really did not understand the question with the C4 indicator was almost twice as high. This is because, students are still memorizing formulas and do not master the concepts well. Students also had difficulty in reading the longitudinal wave image on the slinki, could not determine the wavelength correctly, and had difficulty in distinguishing between the frequency formula and the wave period.

In question number 3, a problem is given about a rope that is moved twice so that in the same time and amplitude it has a different wave pattern. In this question, images of waves A and B are also presented which have different wave patterns. Based on the data that has been presented, students are expected to be able to evaluate the correct statement if they want to make more rope waves in the same time. When students have understood the concept of the relationship between speed, wavelength, and frequency, then students will be able to solve this problem more easily. However, what students face is the difficulty in understanding questions with indicator C5. As many as 37% of students were unable to understand this question well, where 19% of them showed that they did not understand the question very well because of the difficulty in analyzing the phenomena presented. Not only that, students also have difficulty in determining the existing quantities correctly and connecting them with the concept of the relationship between speed and frequency of waves. Furthermore, in question number 5 which is also a HOTS question with indicator C5, students are given data on the frequency and speed of sound waves emitted by bats. Based on insect size data, students are asked to evaluate the smallest type of insect that can be detected by the bat based on its wavelength. In this question, half of the students who understand question number 5 very well are included in the category of those who do not understand this question. Based on the students' essay answers, it is known that students experience difficulties that are almost similar to question number 4, where students have difficulty in analyzing the phenomena in the question, understanding the quantities in the question, and are less able to connect the concepts of propagation speed, frequency and wavelength.

In question number 5 which is a HOTS question with indicator C6, students are given a reading about seismic waves generated by earthquakes. Based on the reading, students are asked to analyze the factors that cause waves to be detected more quickly and evaluate conclusions about the location of the seismograph so that earthquakes are detected quickly. This question has a higher level of complexity compared to the previous question. More than half of the students were unable to understand this question well, so it affected the students' ability to solve problems in this question. Based on the point scores in the students' answers, it is known that most students have difficulty in recognizing the quantities in the question. Students also have difficulty in interpreting the reading and image information presented. In addition, quite a few students also solve the problems in this question with inappropriate stages.

Eventually, it is important to consider effective learning strategies that prepare students to engage with HOTS questions. HOTS questions are designed to help students master higher-order cognitive skills (Nisfah et al., 2022; Nurhayati et al., 2021). If a significant number of students are still struggling with these assessments, then there may be a misalignment with the learning strategies being implemented. According to Kanyesigye et al. (2022), low levels of students' higher-order thinking skills can stem from students' errors in understanding abstract concepts, lack of mathematical operational skills, and lack of mastery time during learning. The inherent complexity of HOTS questions challenges educators to critically assess whether their teaching practices are aligned with HOTS cognitive goals (Pane et al., 2021; Yulianti et al., 2018) and provide students with the scaffolding needed to develop these skills (Mamun & Lawrie, 2023). Learning independent and self-regulation play an importan role in the development of students' HOTS skill (Rezeki et al., 2024), and scaffolding can support these needs. Yana et al. (2023) and Handayanto et al., (2024) found that providing appropriate and appropriate scaffolding can improve students' scientific reasoning, which can make it easier for students to understand questions and master HOTS skills (Meilina

et al., 2020; Sobirin et al., 2019). In addition, peer scaffolding learning strategies may also be applied in collaborative learning, so that students can help each other tackle challenging concepts and their collective understanding of HOTS can also improve (Handayanto et al., 2015; Koes-H et al., 2020; Rashid et al., 2017).

CONCLUSION

Based on the discussion analysis, it is concluded that although the overall understanding of vibrations and waves among junior high school students shows promising results, the results highlight significant gaps in their ability to engage with higher-order thinking skills. The findings can serve as a starting point for making necessary adjustments in the curriculum and methodology of junior high school physics teaching. Educators should reflect on their teaching strategies and curricular approaches, ensuring that they not only effectively convey basic concepts but also encourage the development of critical thinking skills. By prioritizing higher-order thinking in complex scientific contexts, educators can better prepare students for the challenges of the future. Future research should focus on identifying specific teaching practices that can bridge the gap in understanding, particularly for complex concepts as assessed in indicator C6. In this way, we can better equip students with the tools necessary to navigate the complexities of scientific inquiry and application.

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